Healthcare Information Systems Supported by RFID and Big Data Technology

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***Abstract* – This paper proposes a secured radio-frequency identification for smart healthcare environment with specialized system functionalities in order to enhance the quality of health service by improving healthcare, unique patient identification, specialized message delivery and activity related with patients rescue. Big Data part is presented for the analytic and data processing purposes in Health Care Information System, for massive data analysis and their visualization. In this paper we demonstrate how proposed prototype of information system can significantly improve daily emergency and healthcare operations and shows its benefits.**

I. INTRODUCTION

Radio Frequency Identification (RFID) [1,2] and Near-Field Communication (NFC) [2] is the fastest incoming technology in the recent years used to identify items, assets, products, humans or animals. RFID is the technology, which allows unique identification by using radio waves. NFC technology is specialized subset of that technology within the family of RFID technology. NFC is a branch of High-Frequency (HF) RFID and it has been designed to be a secure form of data exchange and NFC device, and is capable of working as NFC reader and an NFC tag. Any system based on RFID or NFC technology [2] can be successfully deployed in many sectors where the emphasis is on the fastest and accurate information processing and immediate transfer of the loaded data for subsequent processing.

Big Data [3, 4] definition is relative today, very attractive and popular. Big Data can be defined as all data that is not a fit for a traditional Relational Data Base Management System (RDBMS), regardless of its use, for online transaction processing (OLTP) or analytic purpose. Big data are not only associated with the size of the data, but most important with the format of the data.

Medical technologies are used by healthcare organizations and their workers to enhance operational efficiency and reduce workload on their professional side. The level of information technology used in medical institutes is already quite high, and based on that the amount of data are growing in line with Big Data trends.

Most researches of the applications of RFID technology in medicine are focused on emergency to automatically identify: people – locating hospital staff and patients tagging for error prevention, objects as blood products, medication and locating assets. RFID is technology that saves lives, prevents errors, saves costs and increases security.

To support a standard medical and specialized hospital practices we are moving from relatively ad-hoc and subjective decision making to the new challenges in healthcare based on Big Data technology.

As an example of taking care of a patient through specialized conceptual Hospital Information System we demonstrate usage of RFID and NFC elements through specialized mobile applications running on smart phones, tablets, and also by using standard PC mobile clients. An Android/iOS based client is used to identify, collect and exchange patient healthcare information with the backend Hospital Information System based on Big Data principles. Within this utilization it is advantageous to use options of RFID/NFC and establish control of taking medical patient care through the Specialized Hospital IS and its life cycle.

This paper is organized as follows: Section 2 gives details about RFID and NFC and their physical characteristics. Section 3 introduces use case scenario of emergency care and smart care hospital principles and its processes. Section 4 presents the system architecture of proposed solution. Section 5 and Section 6 describe principle of Smart Health Care Hospital IS and its functionalities and also new Big Data challenge in Healthcare Information Systems.

II. SMARTER HEALTH

Nowadays healthcare is becoming smarter and it revolutionizes our life. The smart healthcare hospital offers a number of advantages:

- Provides a beneficial strategy for the better healthcare services
- It helps to manage and integrate complex healthcare functionality
- It helps to integrate ICT technology, their products and services
- It supports developing and building new educational models and learning/teaching strategies at no risk to patients
- Continual emphasis on patient and welfare environment and satisfaction

Deployment of smart healthcare hospital information system in particular hospital settings will involve development and implementation of modern technologies and their integration with existing information systems.

A. Big data challenges in healthcare

Big data is a broad term for data sets, so large or complex that traditional data processing applications are inadequate. One way to describe characteristics of Big Data and help us to differentiate data categorized as “Big” from other forms

of data is through the five letters V - "5Vs" [3]. They are Volume, Velocity, Variety, Veracity and Value.

Data volume attributes provide representation of the large volume of data being created on daily bases. Velocity attribute of big data is about fast speed of data, which arrive, and are accumulated within the short period of time. Variety is about the multiple formats and data types that need to be supported by information systems. Veracity refers to the quality or fidelity of data and Value is dependent on how long data processing takes.

The amount of healthcare data that exists in Healthcare information system is growing faster than we expected based on the large amount of historical data, data driven by record keeping, based on legal, regulatory and compliance requirements. Rapid digitization in healthcare is one of these massive quantities of data, which are in line with big data described in primary attributes, "5Vs".

Big Data Challenges in Healthcare are as follows:

- Deducing knowledge from complex and heterogeneous sources for the patients.
- Understanding unstructured clinical notes in the right context.
- Efficiently handling large amount of medical data.
- Analyzing medical data.
- Capturing the patient's behavioral data through several sensors.

B. RFID and NFC sensing technology

RFID and NFC are wireless sensing technologies based on electromagnetic signal detection with automatic identification. Radio frequencies are used for communication with other appliance or items called RFID tag, by using RFID reader. RFID tag is a small object like adhesive sticker that can be attached or incorporated into a product. RFID tag has antenna connected to an electronic module (chip). RFID reader is device which can read unique information stored in RFID tag and transceiver to respond by sending back information to backend information system.

Passive RFID tags are priced significantly cheaper, have different special reading distance from 0.5m to 10m, long lifetime tag using method. Tags that operate at the highest frequency UHF, have radius - about 3-10 m. On the opposite side, the lowest frequency of 125 kHz LF have a range of only about 0.5 m. Therefore passive RFID tags are widespread used in many hi-tech solutions. Due to a several applications of RFID technology in medical identification application, we had a passive RFID wristband bracelet in the 13.56 MHz, which is also NFC enabled bracelet.

C. Use Case scenario in emergency care and smart care hospital

RFID or NFC technology can contribute to create Smart Hospital Healthcare Information System [5]. We can distinguish two use case scenarios:

- Simplified Emergency Care
- Simplified Hospital Care

In Simplified Emergency Care scenario, on emergency arrival, patient receives a wristband with an embedded RFID tag storing all the information related with emergency occurrence. Rescuer collects patient's information as patient's identity, patient's position, insurance company, photos, as well as rescuer identity, and transmits the information to the back end system. Rescuer and other staff members wear a smart RFID badge storing their Id number, rescue car identification etc.

In Simplified Hospital Care scenario, doctors, nurses, caregivers and other staff members also wear a smart RFID badge storing their Id number, Name, Specialization, etc. On arrival, each patient has stored unique identifier, and other personal information as Patient Id, Name, Surname, Gender, Date of Birth, Blood type, Insurance Company Id etc.). All the patients' medical procedures, medical histories and other important information are stored in Smart Healthcare Information System based on RFID label.

III. SYSTEM ARCHITECTURE

Proposed system encompasses three-tier architecture combined with front-end devices (RFID tag, RFID reader). As a client, Smart Health IS uses mobile device (Smartphone, Tablet, RFID reader), wireless communication technologies to integrate and simplify human to application and human to human interaction.

This concept shows secured communication based on modern and new technologies (RDBMS and Big Data) for emergency service and their communication for Internet and intranet users. Smart Heath care Information System architecture is shown on the Figure 1.

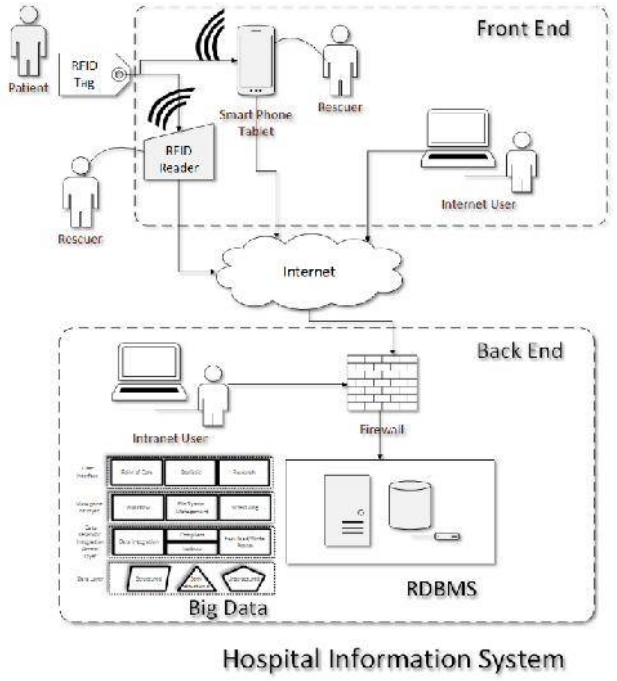

Figure 1. Smart Healthcare High Level Architecture

The architecture of a system for Smart Health Care should have the Front-End part and Back-End part of Hospital Information System.

Front-End part of Hospital Information System has following modules:

- Smart phone/tablet with an Android, iOS or Microsoft OS based smart platform and specialized mobile application shown in Figure 2, Figure 3 or Figure 4. This is the entry point of data which are collected

based on the information from "RFID Tag". In this stage Rescuer collects the data as follows: Patient's Id, Name, Surname, Gender, date of Birth, Country, City, Social Security number, Insurance Company etc. The data collection is fully automated based on RFID tag (Wristband) and the information a patient has given to the Rescuer. Afterwards, collected data are transferred to the Back-End Information System via the Internet. After transfer and collection of data in Back-End part, data are being processed on daily bases in "Smart HCIS". Hospital Information System generates Datasets [3], which are being transferred to the Big Data part of "Smart HCIS" for data analysis, processing and visualization.

- Mobile device - this is also Front-End part of the information system which is Microsoft OS, Linux or OS X based connected with RFID Reader via Bluetooth or WiFi. The Data collection is organized via RFID Reader to the Mobile Client and also transferred as in previous scenario to the Back-End system via Internet.

In Back-End part of the Hospital Information System we are distinguishing two functional parts:

- Data processing part – this module gathers patients data and also collects all the data concerning examination and therapy phases of a patient healthcare life cycle.
- Big Data part – this module gathers structured, unstructured and semi-structured healthcare and operational data about patients, diseases, provided medical services, financial and operational data, clinical data, patient's treatments, risks for diseases. Structured data are data that can be easily stored, queried, analyzed and this data are stored in Relational DBMS. Unstructured and semi-structured data are representing the information that typically requires a human touch to read, capture and interpret properly by analytic tools in this Big data part of Healthcare Information System. This module includes medical imagining, laboratory, pharmacy, insurance and other administrative patient's data.

IV. FRONT-END ANDROID SMARTPHONE CLIENT – "SMART-HCLIENT"

This section presents front-end client, named "Smart-HClient". This application is developed for smart devices with Android OS based on contact-less technology (near-field communication) [6]. Application improves connectivity and coordination between medical team members, helping clinicians respond faster to critical patient events. Smart client (smartphone and RFID reader) allows rescuing worker to send and receive emergency messages at any time and any place. The worker also collects patients' information as Name, Surname, Gender, Location Coordinates, Blood type, Insurance Company Id etc.

Smartphone application as "Smart HClient" for emergency and hospital message delivery is registered with Smart healthcare information system within account name and password. Once the registration is completed, the system checks whether the user operating this device is sending or receiving relevant emergency messages correctly.

The smartphone operation is described as follows:

- Healthcare employee activates the smart healthcare notification system with their smartphone or RFID reader.
- The employee inputs his username and password.
- Smart health care information system verifies the worker's identity.
- Once the logon procedure is completed, the smartphone, RFID client shows the system menu (see Fig. 2, Fig. 3, Fig. 4). The system then starts the message collection and transceiving.
- Upon reaching the patient, the healthcare worker starts the rescue. First, the healthcare worker confirms patient's identity. Second, the healthcare worker checks and know what's the correct rescue that patient really need.
- Smartphone application client has its local database and independently collects the information. Client is communicating with the backend Smart Healthcare information system based on asynchronous principle through web services published on the backend information system and unifies collected information.
- Once the patient is registered by the Smart Healthcare IS and accepted by a hospital medical staff responsible for his examination, the lifecycle continues inside the Smart Healthcare IS through the smartphone application or web browser as a light client.

Figure 2. "Smart-HClient" Patient information

In the Therapy part of "Smart-HClient" application, values as Temperature, Blood pressure, Time, Date, Patient's Id, Location, are being measured on daily basis. This data are structured and transfered to the local database of Healthcare Information System. This data is at the same

time being transferred to the Big Data part of information System for processing and analysis by Big Data Analysts [3].

Figure 3 - "Smart-HClient" Patient therapy

On the patient examination part of Front-End application, there are collected information about diagnosis, medication, Time, Data, Description of disease, shown on Figure 4.

Figure 4 - "Smart-HClient" Patient examination

Patient dashboard part shows the graphical presentation of tracked and followed patient's parameters from previous parts as Examination and Therapy. It allows medical staff to make analysis of patient's health checks in predefined time period, and to make decision for further examination based on previous results, shown in Figure 5.

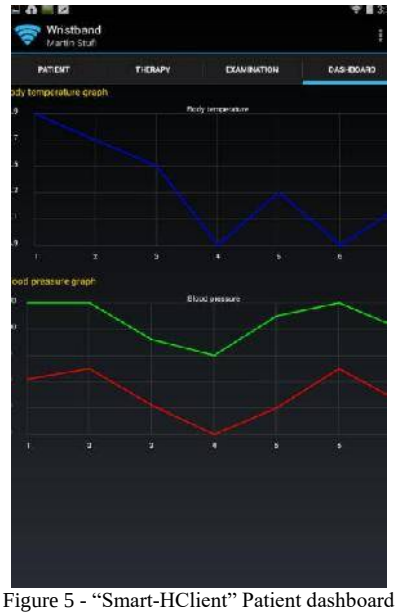

Figure 5 - "Smart-HClient" Patient dashboard

V. BACK-END SMART HEALTHCARE IS – "SMART HCIS"

Backend Smart Healthcare IS can be developed on the best fitting technology, which supports a variety of ways to build Business services, Web services, Java objects, Business Components. In our use case demands, Back-End application was developed such as Service Oriented Architecture [7] with minimal integration effort based on Oracle GlassFish application server for J2EE enterprise application. Our framework follows Model-View-Controller [8] design paradigm. The layered architecture of the framework simplifies maintenance, decouples implementations from interfaces, and improves reusability of the components across applications.

Key functionalities like Create, Edit, Refresh and Manage of Back-End system are shown in Figure 6 – "Smart HCIS" Patient record and Figure 7 - "Smart HCIS" Patient examination.

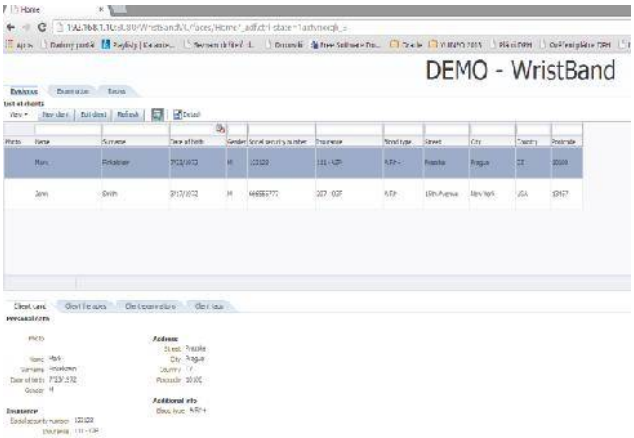

Figure 6 – "Smart HCIS" Patient record

Information related to the patients' healthcare is in the Evidence part, shown in Figure 6. Evidence part collects the data as follows:

- Patient's records (Patient Photo, Patient Cards, Insurance Company, Blood Type Information, Address, Examinations, Therapies, Tags, etc.)

Examination part, shown in Figure 6 collects the patient data as follows:

- Examination (Temperatures, Pressures, Medications, etc.)
- Rooms (Patient location information, Hospitalizations, etc.)
- Medical staff administration

Administration part, shown in Figure 7 is related with application administration of:

- Web Services address settings
- Dashboard settings
- Administrator's console

Web Services Administration part allows administration tasks related with configuring the enterprise application that contains Web Service, starting and stopping deployed application, configuring the Enterprise application, such as the deployment order, session time-out for Web application or transaction type for Enterprise Java Beans (EJBs). Also, this part of administration is needed for creating, updating, monitoring and testing the Enterprise application.

Dashboard Settings is a part of Hospital Health Care Information System related with the application administration. Based on the set of parameters via dashboard, users are able to see visualized [9] and fit data related with a patient as Temperature indicator, Blood pressure and another performance measures which have to be monitored.

Administrator console is a Web browser-based, graphical user interface which is being used to manage GlassFish server domain and their instances, including Web-Services, that are deployed to the server or cluster.

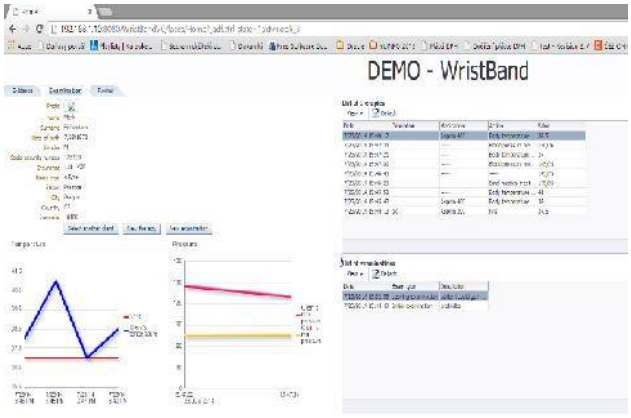

Figure 7 - "Smart HCIS" Patient examination

There are analytic tools in Big Data part of Healthcare Information Systems and their purpose is to derive values from big data and also to help Data Analysts and Data Scientist to prepare valuable information in order to make smart and right decisions by management, which brings competitive advantage for the hospital.

VI. CONCLUSION

This article provides an overview and functioning example of RFID/NFC based mobile medical patient tracking and diagnosis Smart Healthcare Information System and its relationship to Big Data architecture for patient's care, analytic, statistic and research purposes.

Main benefits of smart devices like smartphones, tablets, RFID/NFC readers and other new technologies improve connectivity, responsibility and coordination between medical or hospital team members, helping clinicians respond faster to usual and critical patient events inside of smart healthcare information system. Smart devices provide an important delivery mechanism for combing alert messages with graphic presentation resulting in positive impact on workflow.

Big Data has huge potential to transform and improve the way for a healthcare information system by using sophisticated technology like RFID/NFC. Big Data therefore becomes mainstream in information system governance.

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